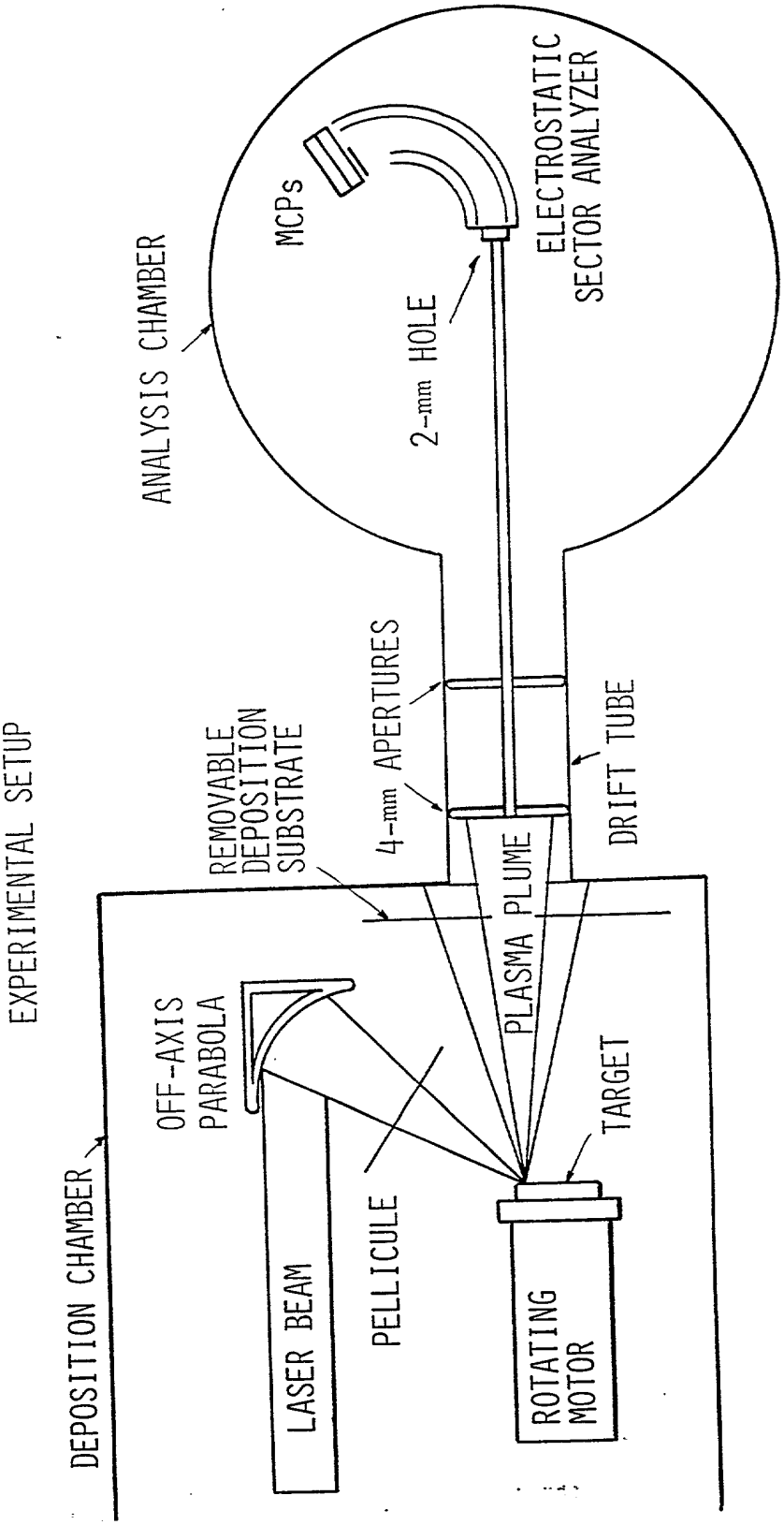

EXPERIMENTAL SETUP
DEPOSITION CHAMBER
OFF-AXIS PARABOLA
LASER BEAM
PELLICULE
ROTATING MOTOR
TARGET
PLASMA PLUME
REMOVABLE DEPOSITION SUBSTRATE
4-mm APERTURES
DRIFT TUBE
ANALYSIS CHAMBER
2-mm HOLE
MCPs
ELECTROSTATIC SECTOR ANALYZER

FIG.1

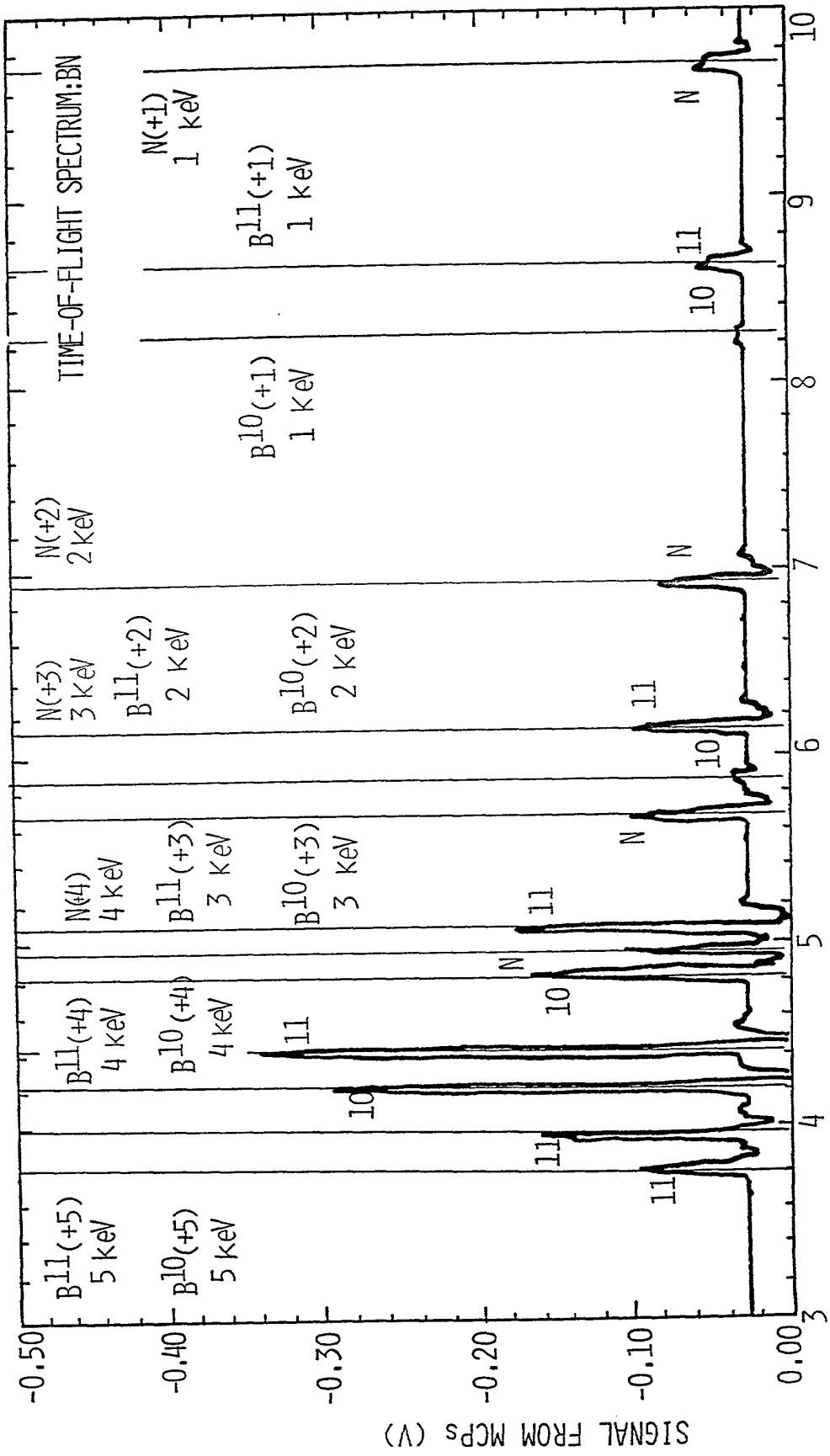

TIME-OF-FLIGHT SPECTRUM:BN
SIGNAL FROM MCPs (V)
-0.50
-0.40
-0.30
-0.20
-0.10
0.00
3
4
5
6
7
8
9
10
ARRIVAL TIME AFTER LASER PULSE (μs)
LASER:200fs,780nm, 50 J/cm2, 4mJ/PULSE,
100μmSPOT,2.5X10^14 W/cm^2
B11(+5) 5 keV
B10(+5) 5 keV
B11(+4) 4 keV
B10(+4) 4 keV
N(4) 4 keV
B11(+3) 3 keV
B10(+3) 3 keV
N(+3) 3 keV
B11(+2) 2 keV
B10(+2) 2 keV
N(+2) 2 keV
B10(+1) 1 keV
B11(+1) 1 keV
N(+1) 1 keV
11
10
N

FIG. 2

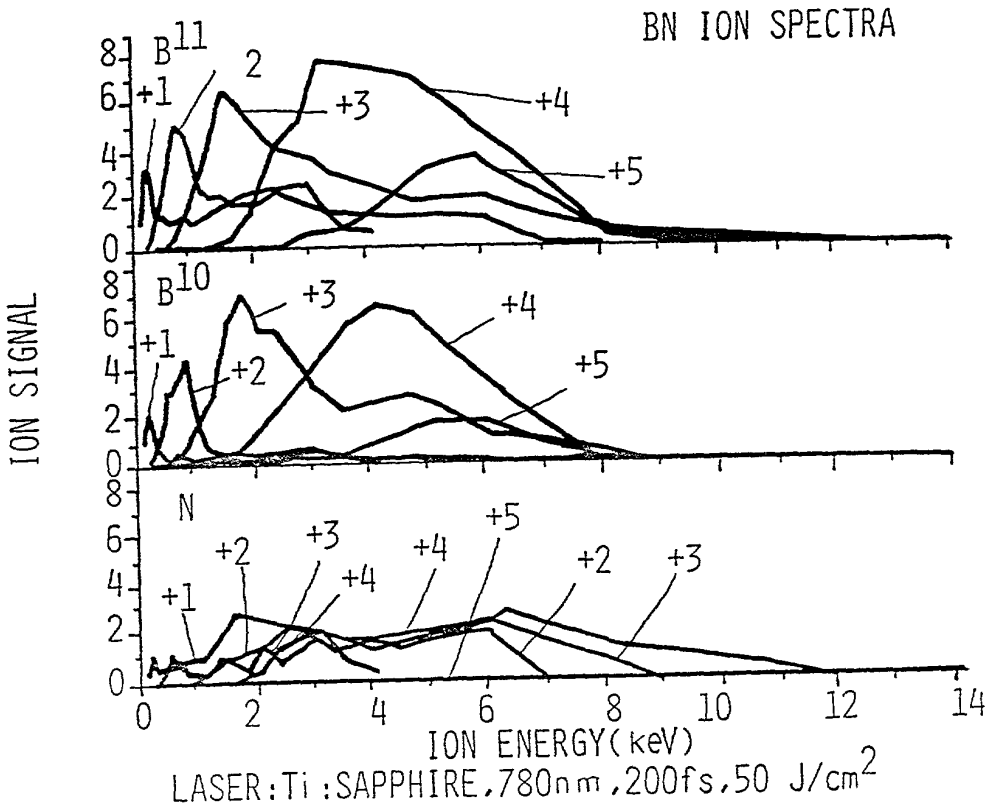


FIG.3A

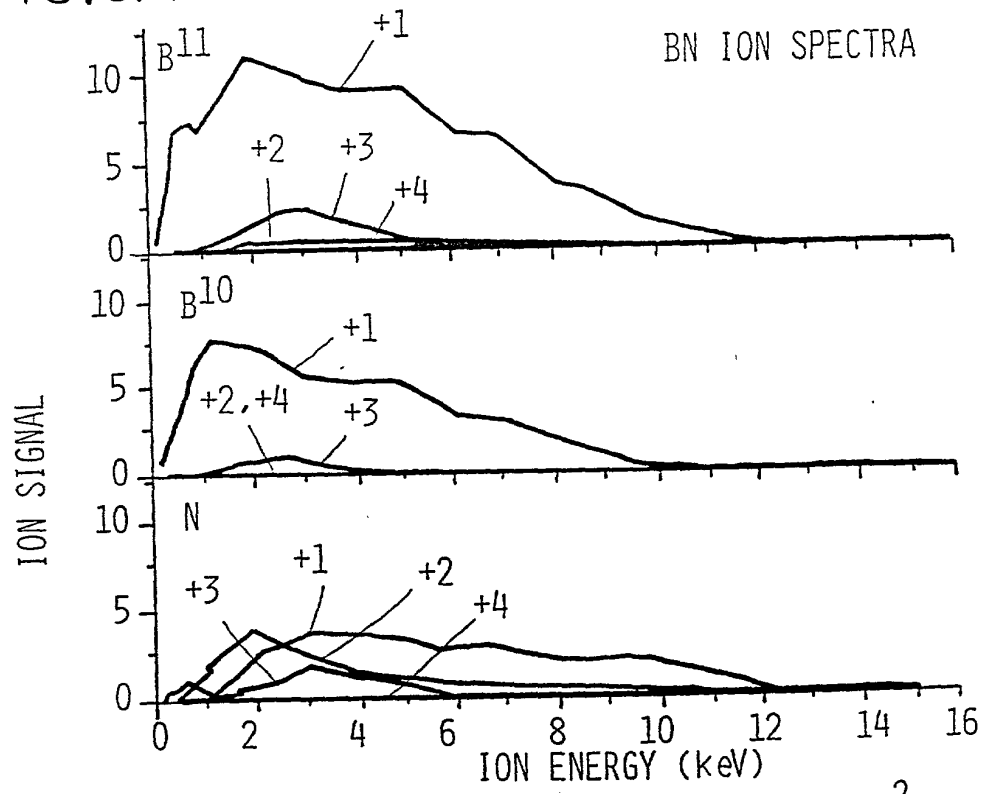


FIG.3B

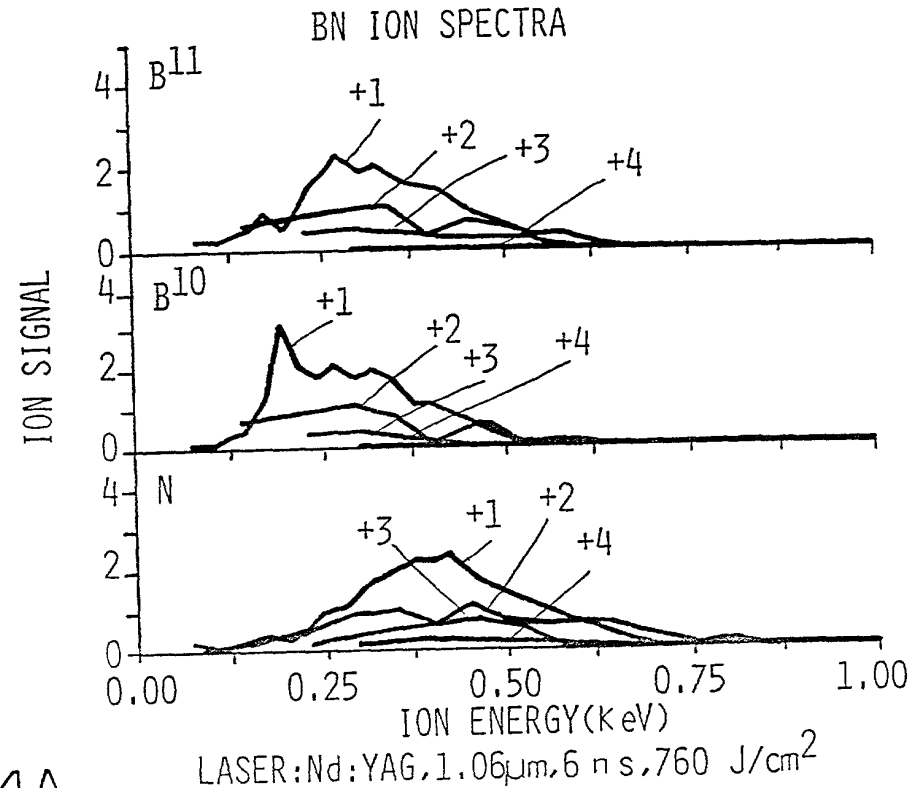

BN ION SPECTRA
B11
+1
+2
+3
+4
B10
+1
+2
+3
+4
N
+3
+1
+2
+4
ION SIGNAL
0.00
0.25
0.50
0.75
1.00
ION ENERGY(KeV)
LASER:Nd:YAG,1.06μm,6 n s,760 J/cm2

FIG.4A

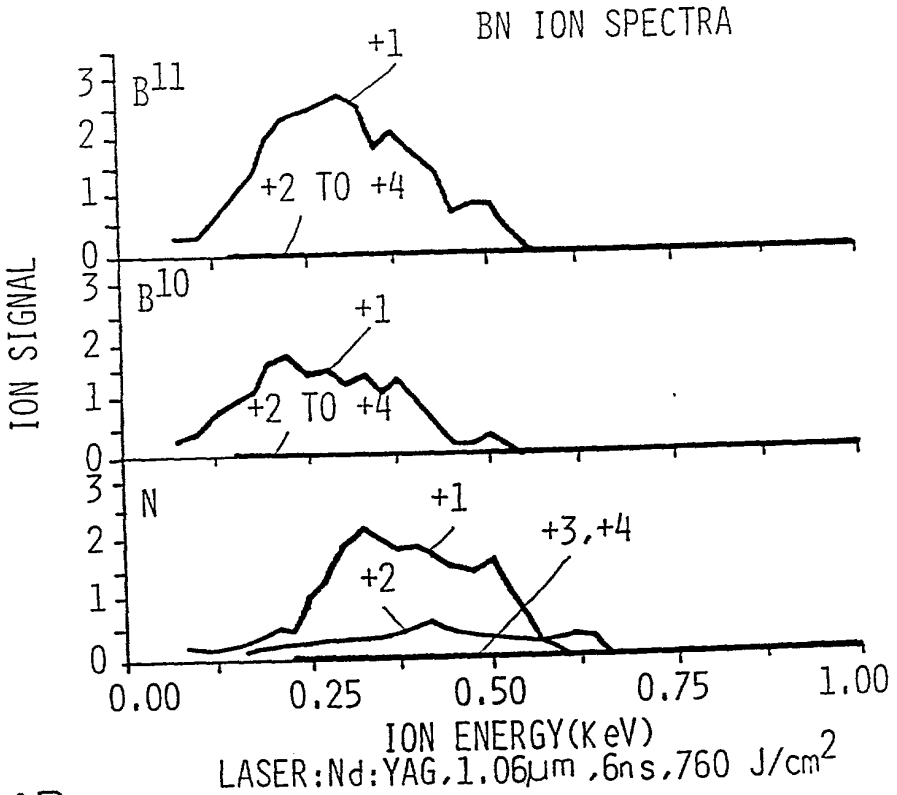

BN ION SPECTRA
B11
+1
+2 TO +4
B10
+1
+2 TO +4
N
+1
+3,+4
+2
ION SIGNAL
0.00
0.25
0.50
0.75
1.00
ION ENERGY(KeV)
LASER:Nd:YAG,1.06μm ,6ns,760 J/cm2

FIG.4B

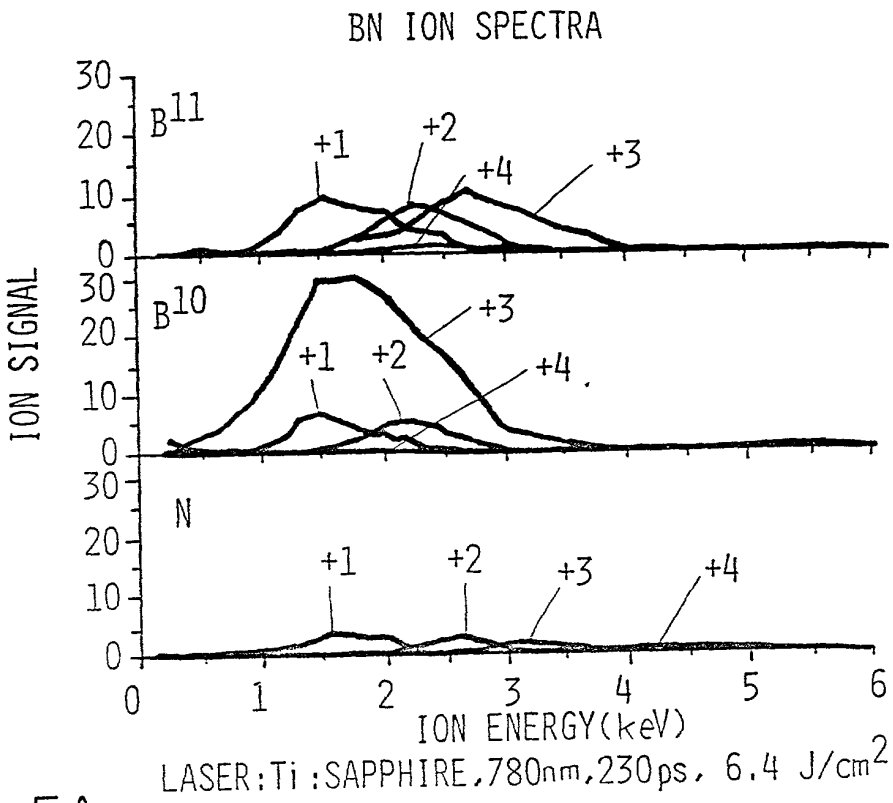

BN ION SPECTRA
ION SIGNAL
B11
+1
+2
+4
+3
B10
+3
+1
+2
+4
N
+1
+2
+3
+4
0
1
2
3
4
5
6
ION ENERGY(keV)
LASER:Ti:SAPPHIRE,780nm,230ps, 6.4 J/cm2

FIG. 5A

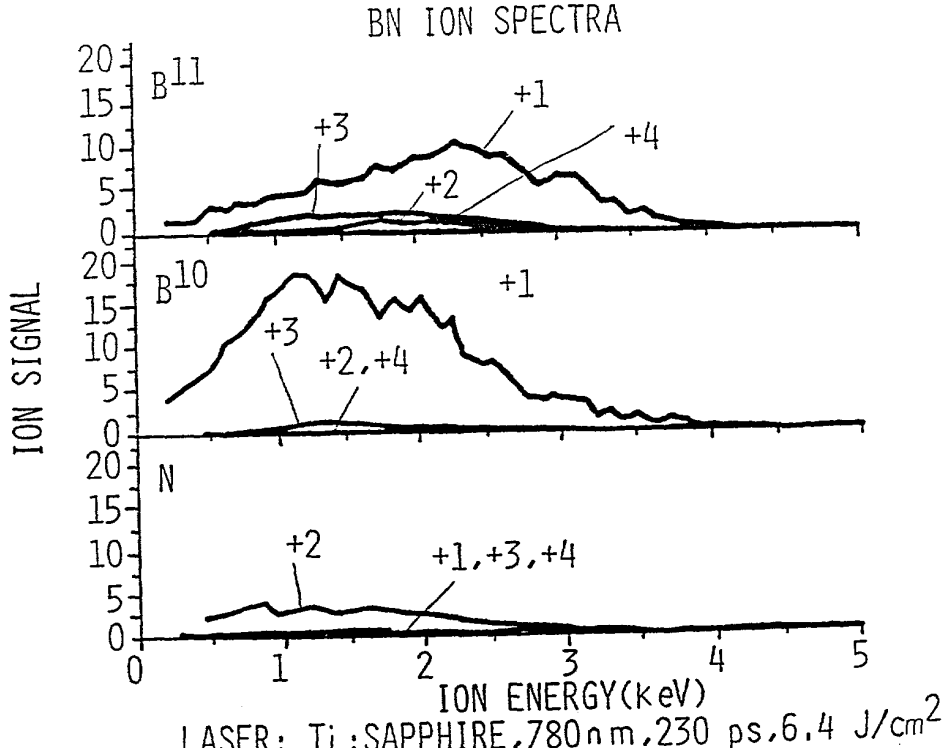
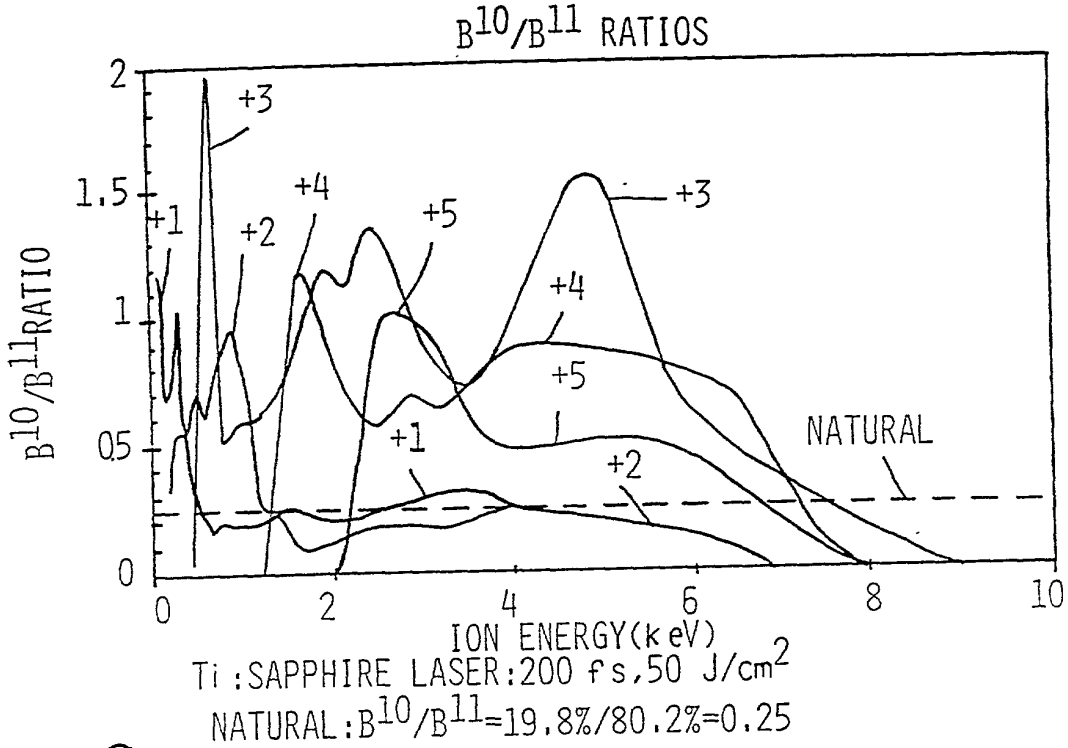

BN ION SPECTRA
ION SIGNAL
B11
+3
+1
+4
+2
B10
+1
+3
+2,+4
N
+2
+1,+3,+4
0
1
2
3
4
5
ION ENERGY(keV)
LASER: Ti:SAPPHIRE,780nm,230 ps,6.4 J/cm2

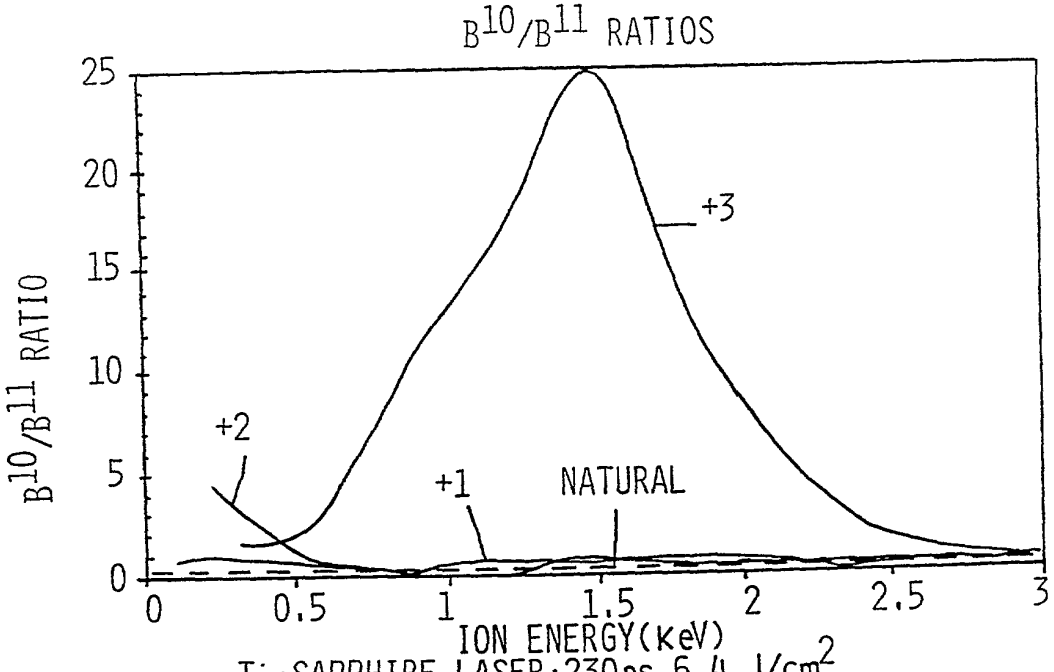
FIG. 5B



Ti:SAPPHIRE LASER:200 fs,50 J/cm^2

NATURAL:B^{10}/B^{11}=19.8%/80.2%=0.25

FIG.6A



Ti:SAPPHIRE LASER:230ps,6.4 J/cm^2

NATURAL: B^{10}/B^{11}=19.8%/80.2%=0.25

FIG.6B

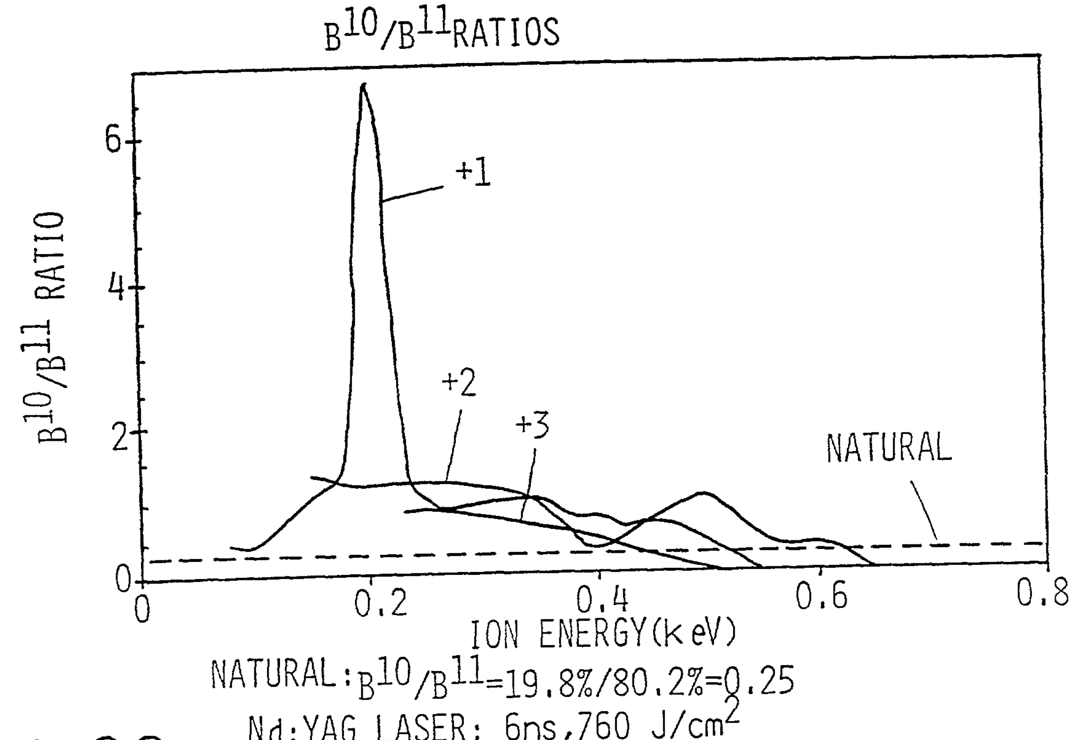


FIG.6C

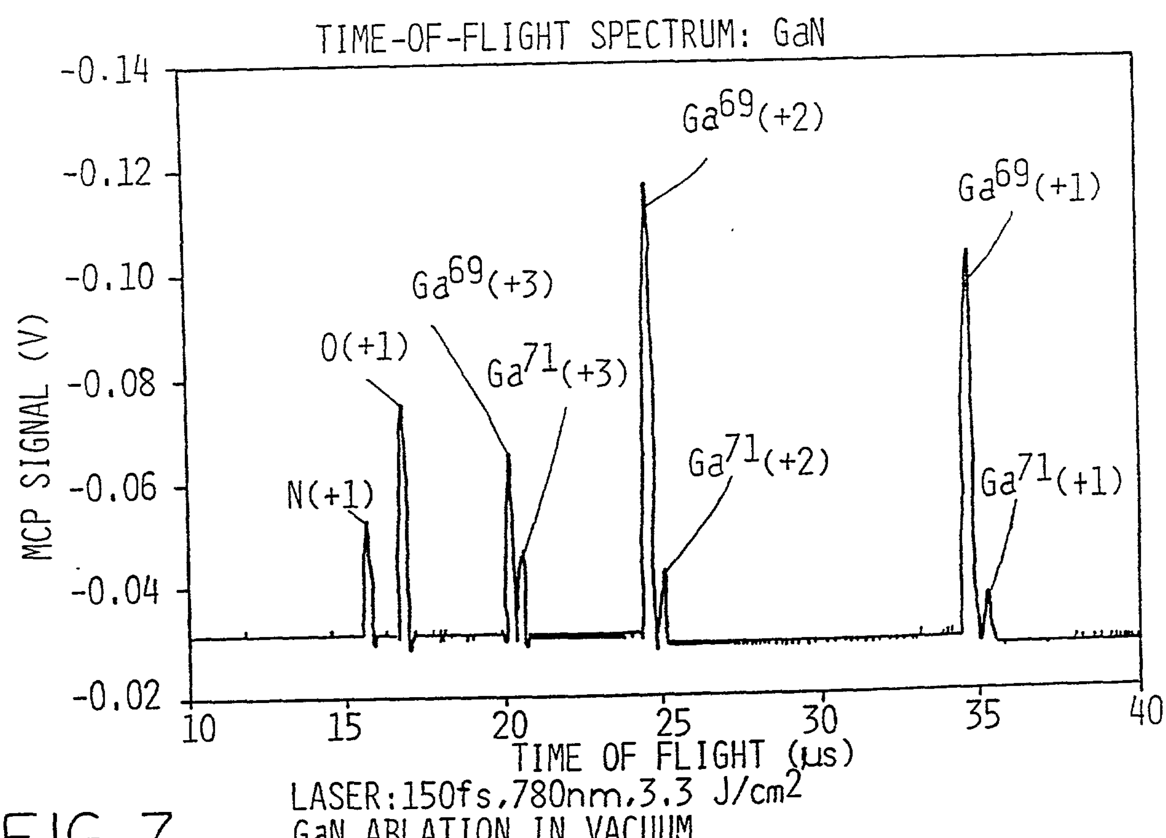


FIG.7

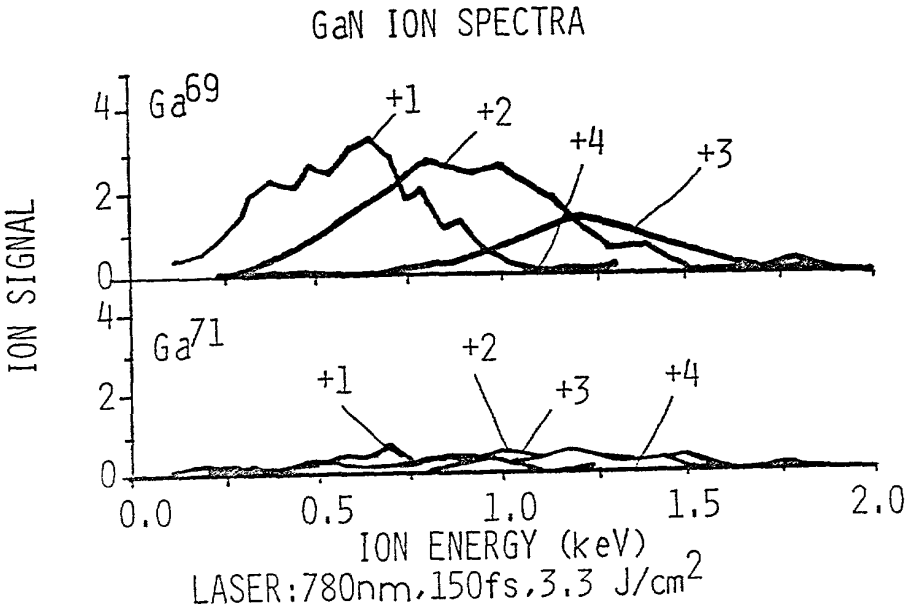

GaN ION SPECTRA
Ga69
+1
+2
+4
+3
Ga71
+1
+2
+3
+4
ION SIGNAL
0
2
4
0.0
0.5
1.0
1.5
2.0
ION ENERGY (keV)
LASER:780nm,150fs,3.3 J/cm2

FIG. 8A

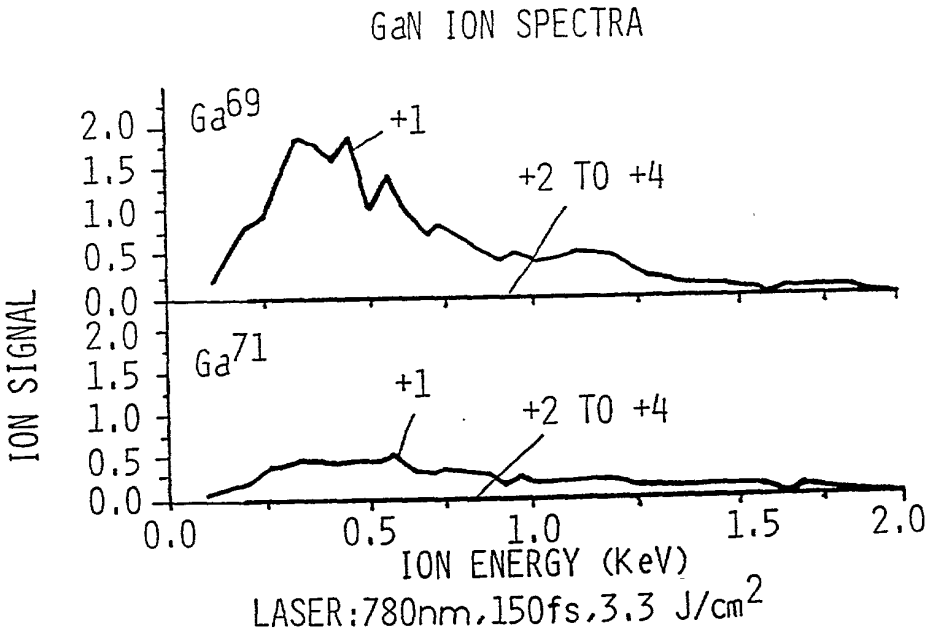
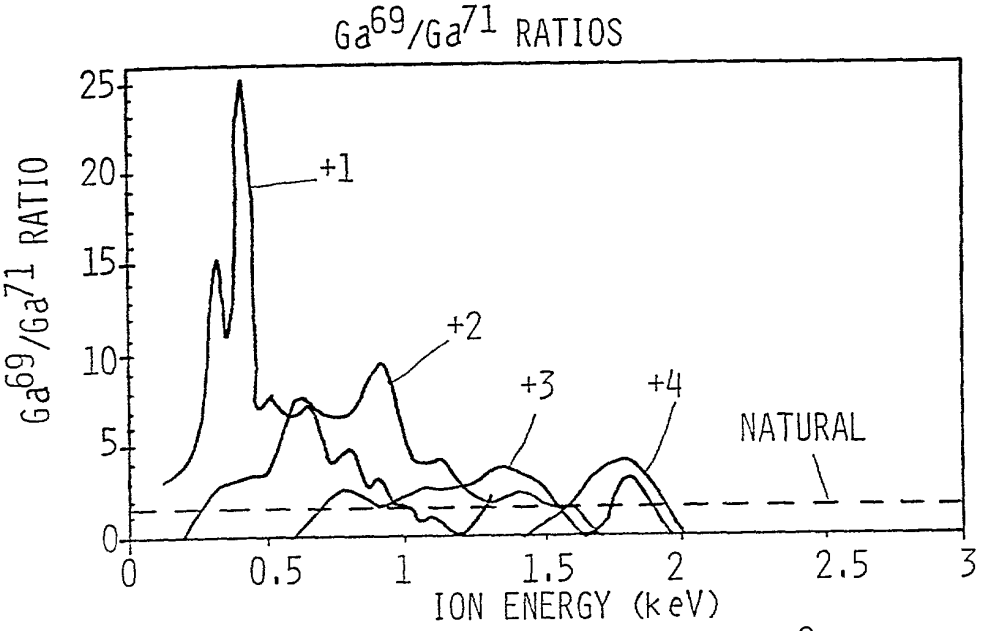
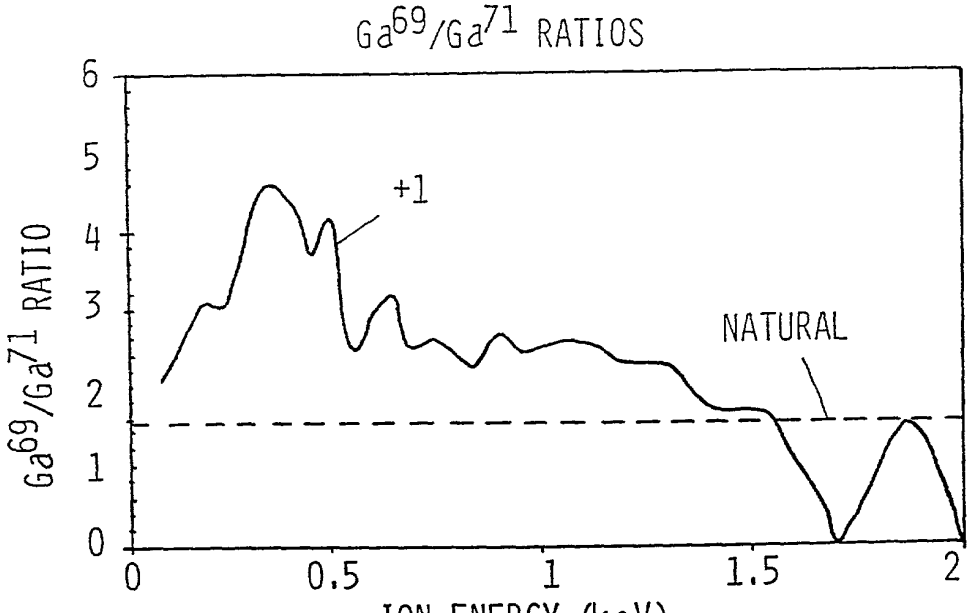

GaN ION SPECTRA
Ga69
+1
+2 TO +4
Ga71
+1
+2 TO +4
ION SIGNAL
0.0
0.5
1.0
1.5
2.0
ION ENERGY (KeV)
LASER:780nm,150fs,3.3 J/cm2

FIG. 8B



Ti:SAPPHIRE LASER: 150fs, 3.3 J/cm^2
NATURAL: Ga^{69}/Ga^{71}=60.4%/39.6%=1.53

FIG.9A



Ti:SAPPHIRE LASER: 150fs, 3.3 J/cm^2
NATURAL: Ga^{69}/Ga^{71}=60.4%/39.6%=1.53

FIG.9B

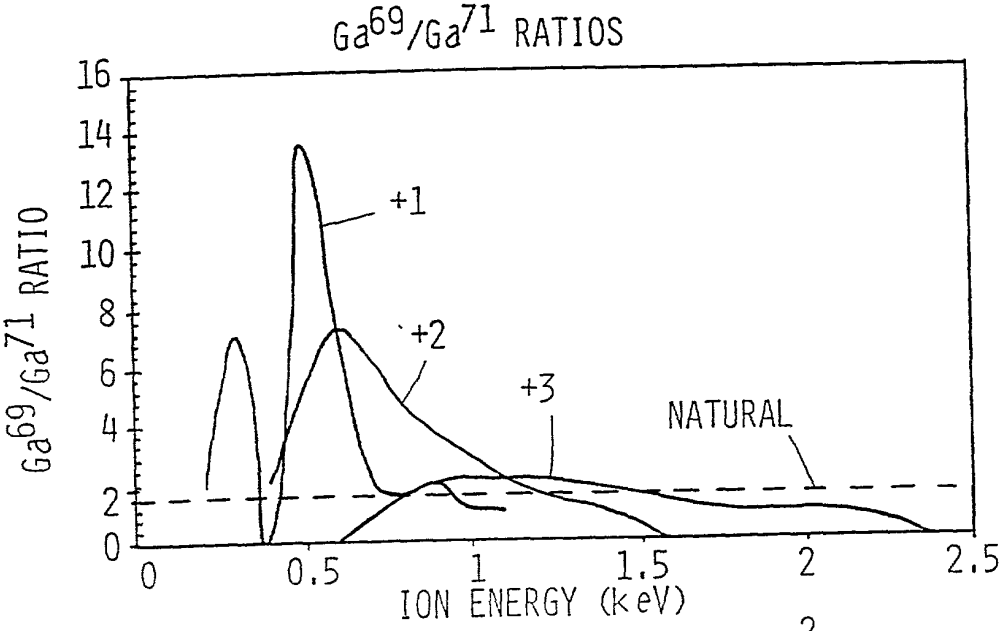

Ga^{69}/Ga^{71} RATIOS
Ga^{69}/Ga^{71} RATIO
16
14
12
10
8
6
4
2
0
+1
+2
+3
NATURAL
0
0.5
1
1.5
2
2.5
ION ENERGY (keV)
Ti:SAPPHIRE LASER:230ps,2.4 J/cm^2
NATURAL:Ga^{69}/Ga^{71}=60.4%/39.6%=1.53

FIG.9C

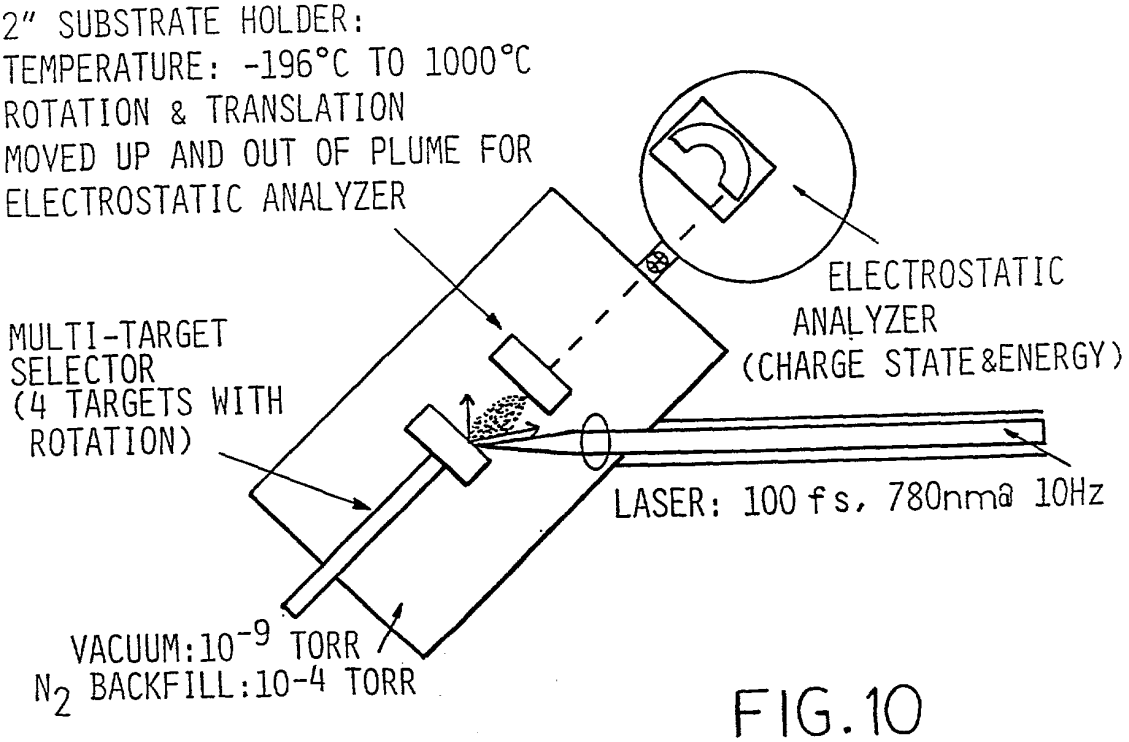

2" SUBSTRATE HOLDER:
TEMPERATURE: -196°C TO 1000°C
ROTATION & TRANSLATION
MOVED UP AND OUT OF PLUME FOR
ELECTROSTATIC ANALYZER
ELECTROSTATIC
ANALYZER
(CHARGE STATE&ENERGY)
MULTI-TARGET
SELECTOR
(4 TARGETS WITH
ROTATION)
LASER: 100 fs, 780nm@ 10Hz
VACUUM:10^{-9} TORR
N_2 BACKFILL:10^{-4} TORR

FIG.10

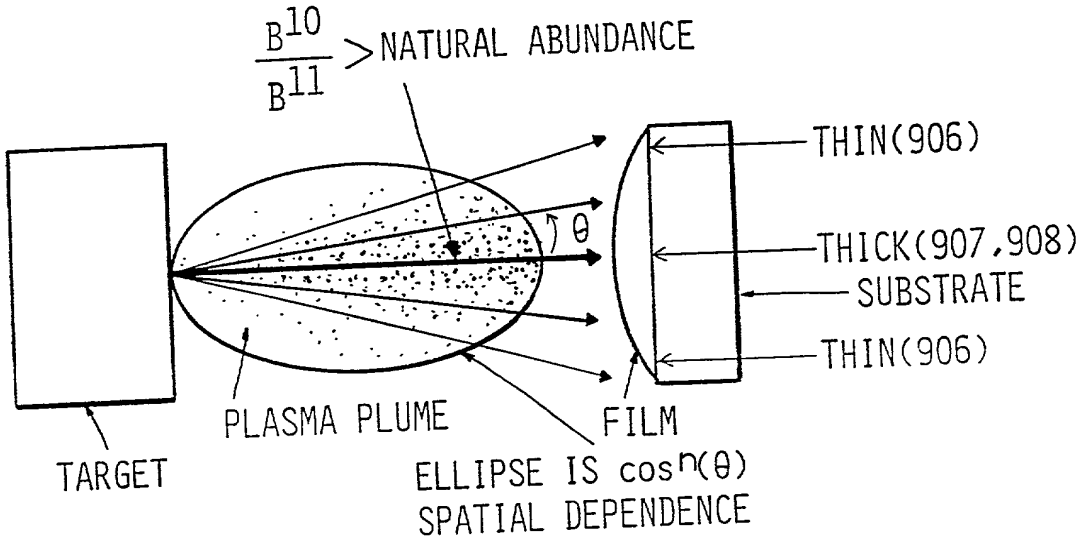


FIG. 11

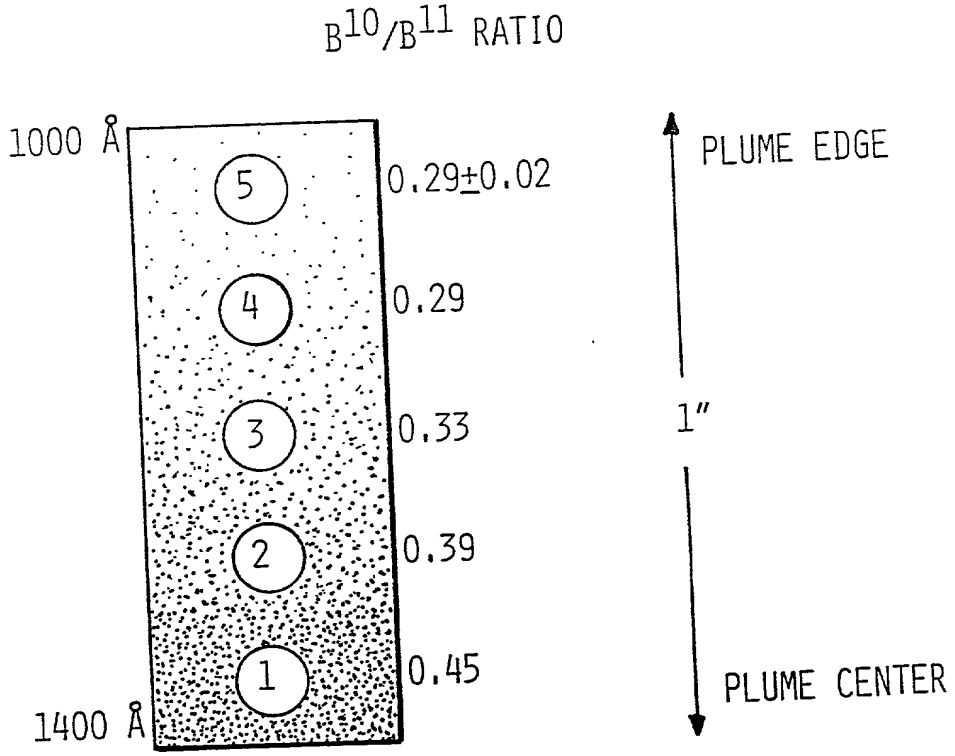


FIG. 14A

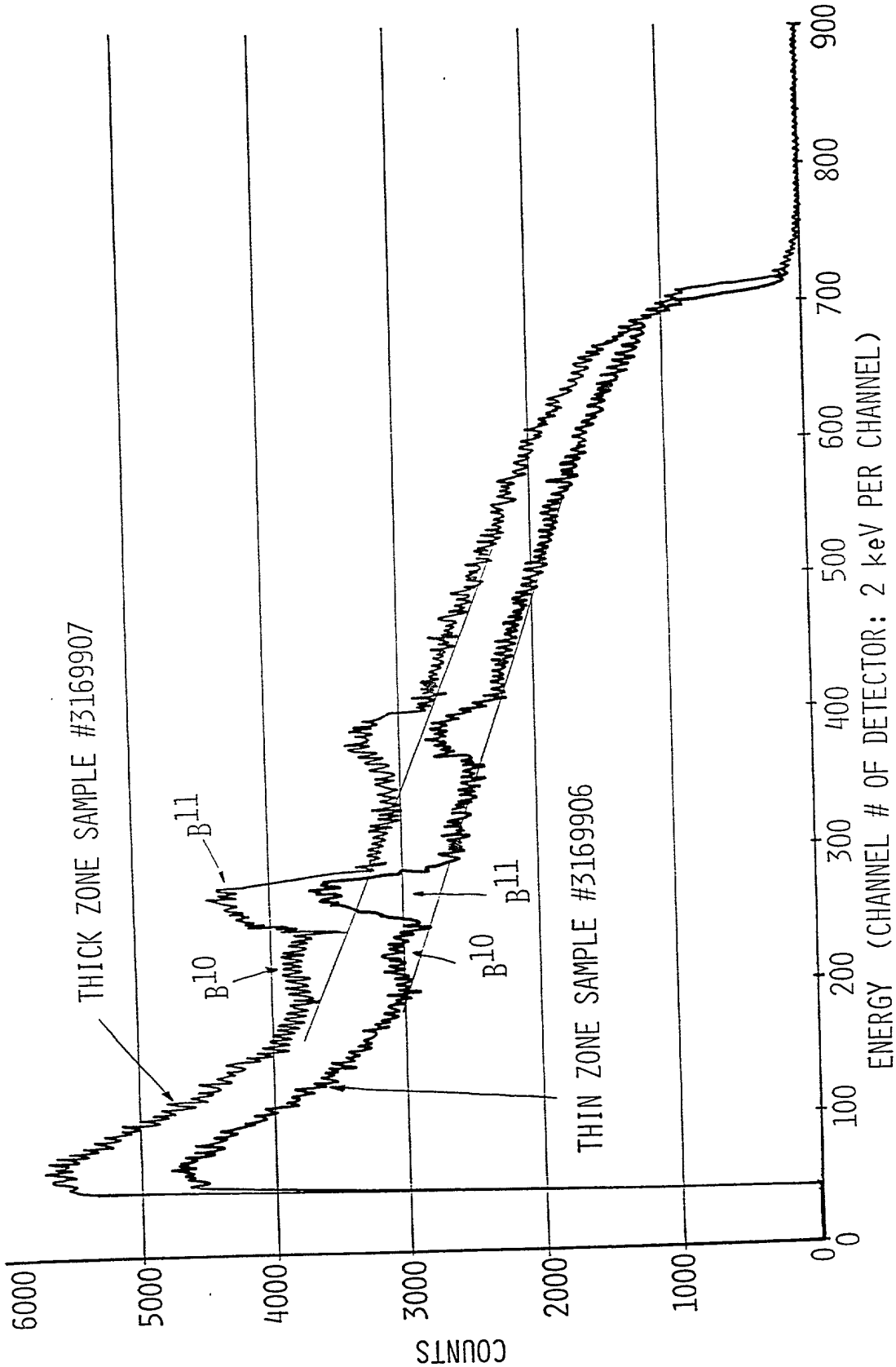

THICK ZONE SAMPLE #3169907
THIN ZONE SAMPLE #3169906
B11
B10
B11
B10
COUNTS
6000
5000
4000
3000
2000
1000
0
0
100
200
300
400
500
600
700
800
900
ENERGY (CHANNEL # OF DETECTOR: 2 keV PER CHANNEL)

FIG. 12

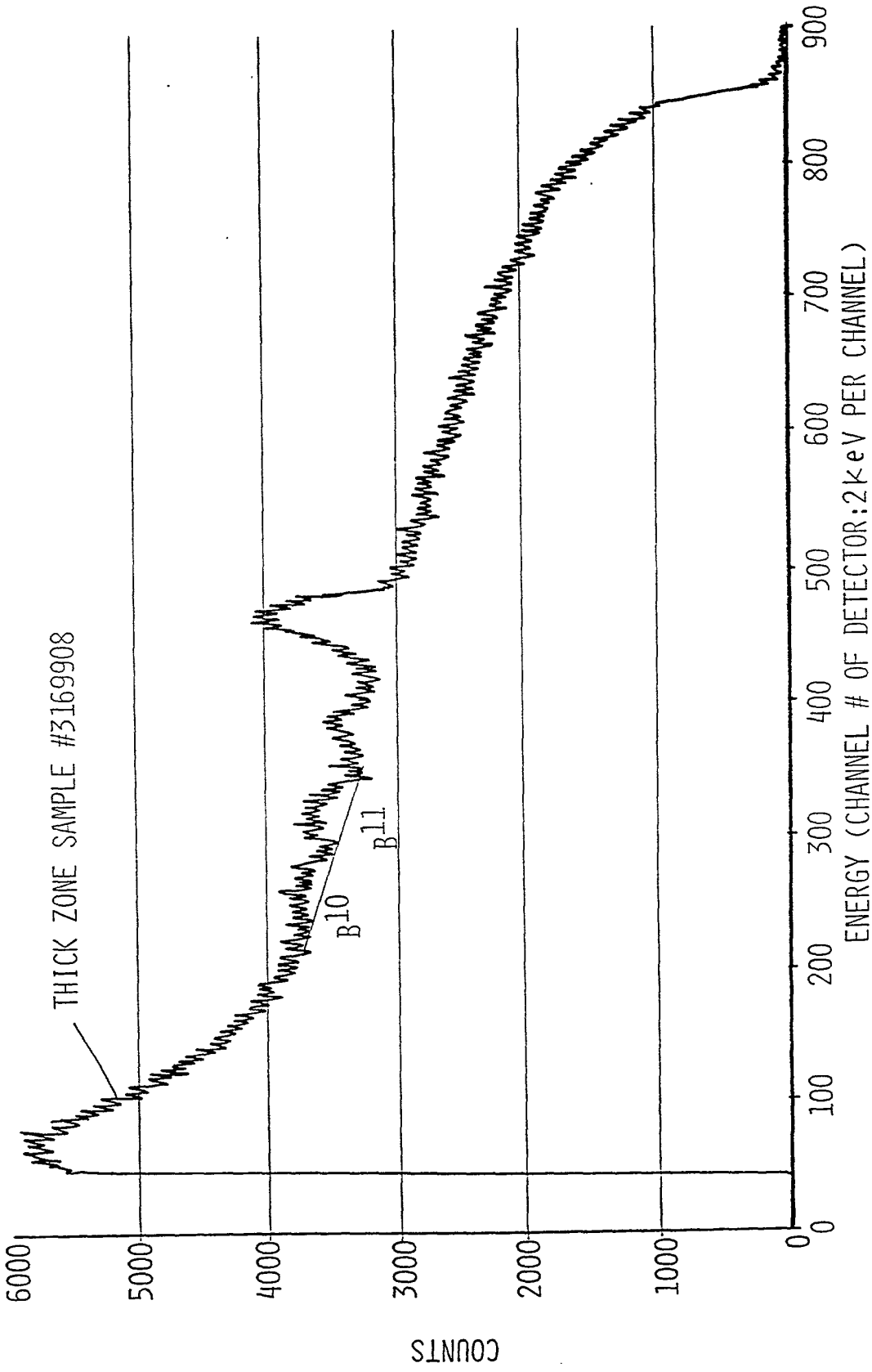

THICK ZONE SAMPLE #3169908
B10
B11
COUNTS
6000
5000
4000
3000
2000
1000
0
0
100
200
300
400
500
600
700
800
900
ENERGY (CHANNEL # OF DETECTOR: 2keV PER CHANNEL)

FIG. 13

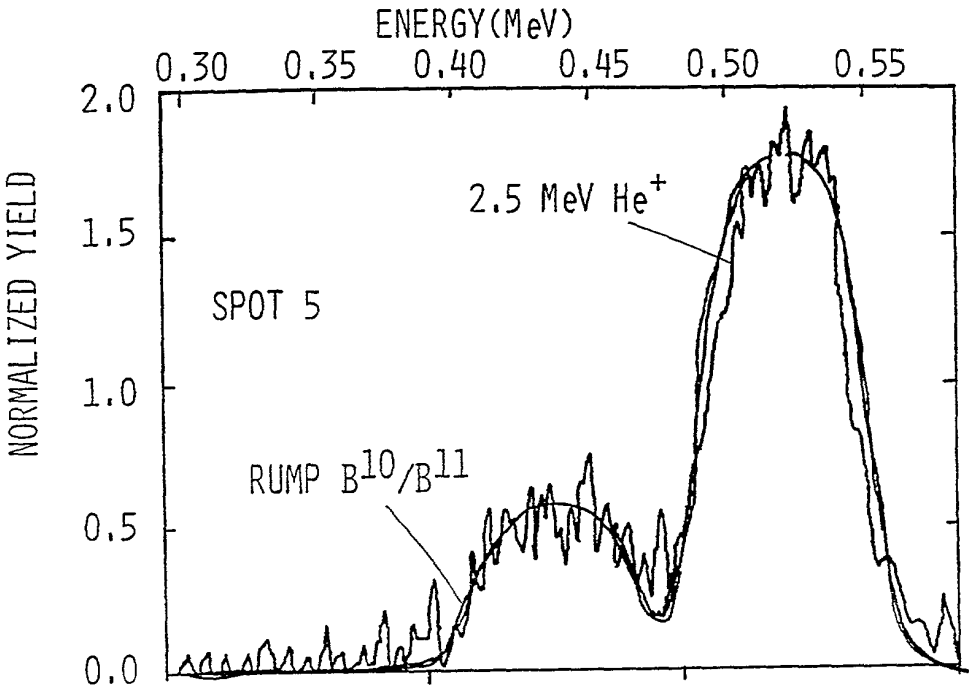


FIG.14B

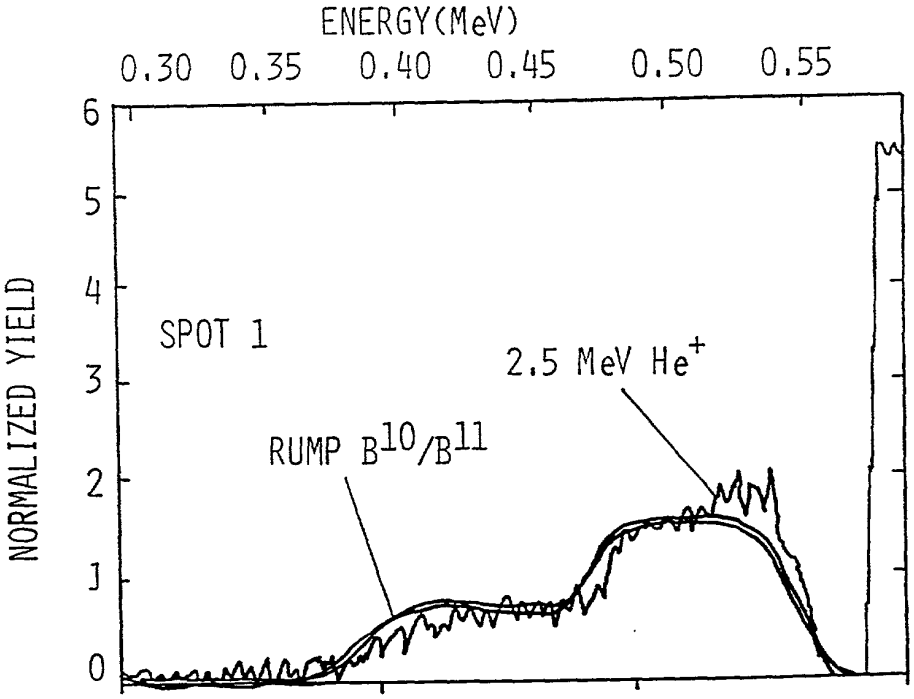


FIG.14C

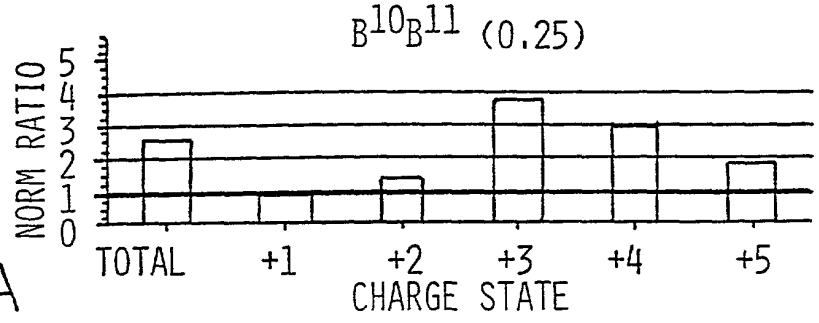


FIG. 15A

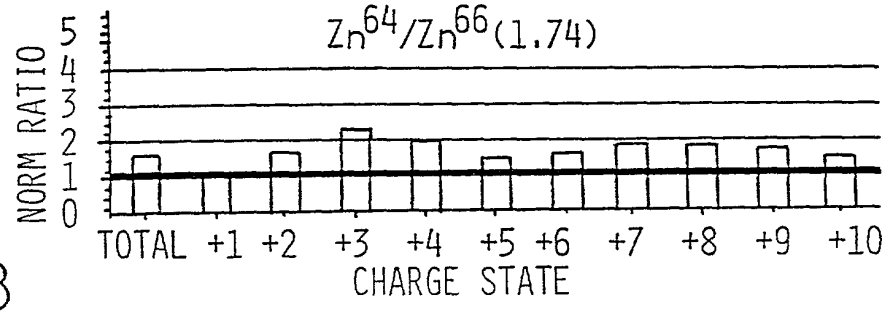


FIG. 15B

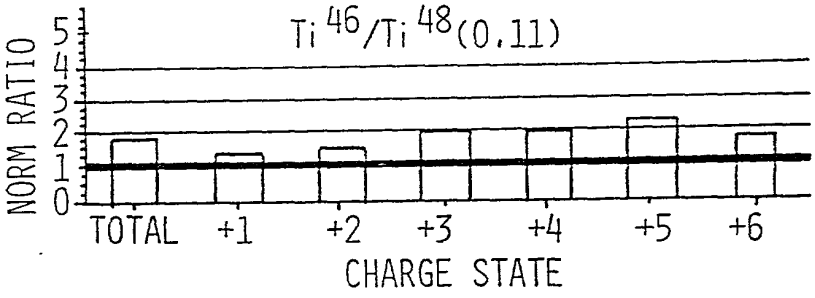


FIG. 15C

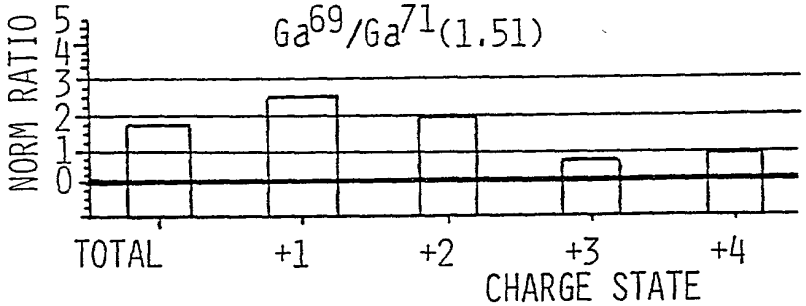


FIG. 15D

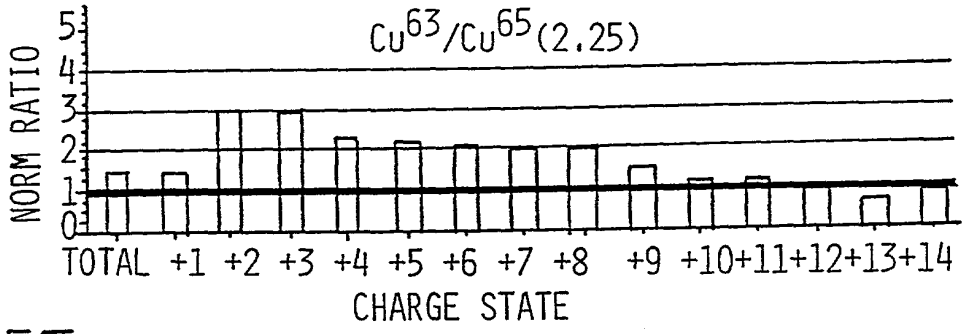


FIG. 15E

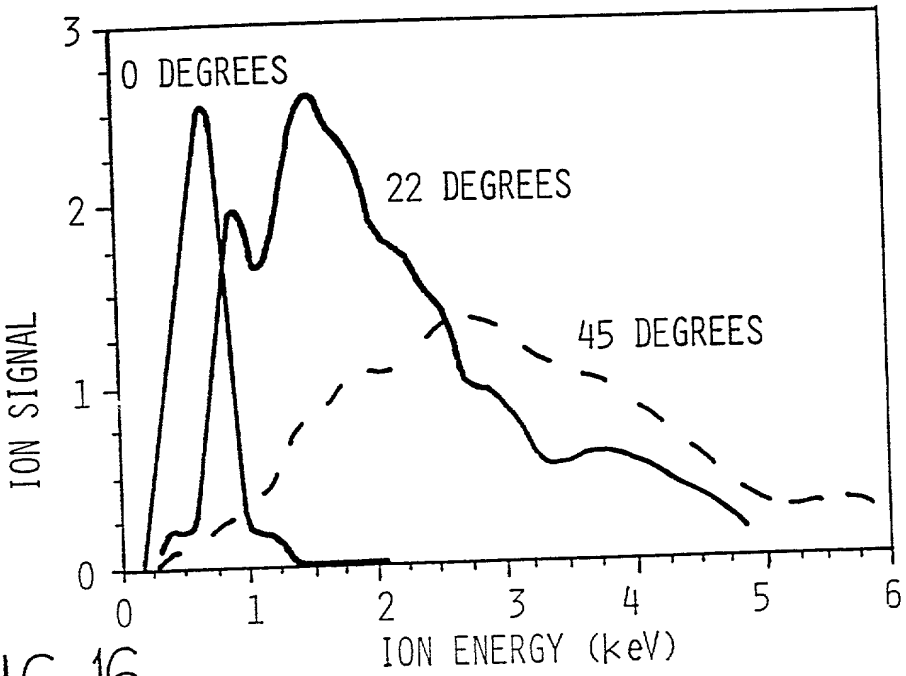

0 DEGREES
22 DEGREES
45 DEGREES
ION SIGNAL
ION ENERGY (keV)
0
1
2
3
4
5
6

FIG.16

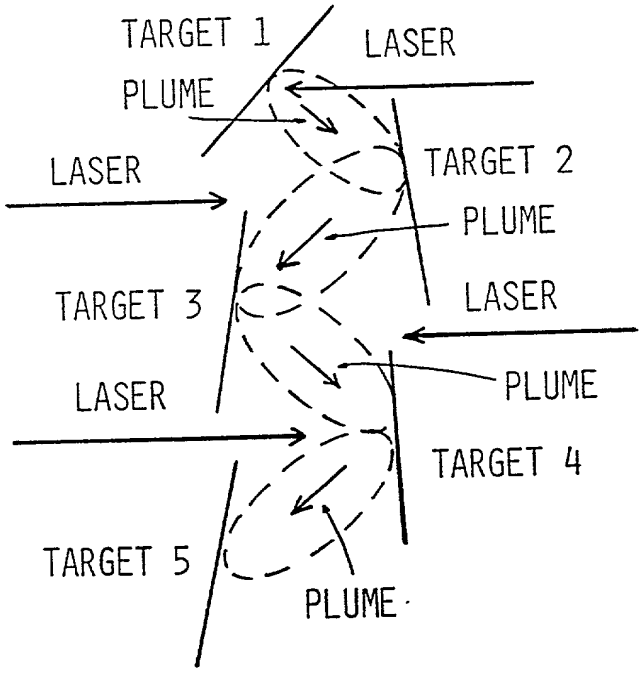

TARGET 1
LASER
PLUME
LASER
TARGET 2
PLUME
TARGET 3
LASER
PLUME
LASER
TARGET 4
TARGET 5
PLUME

FIG.18

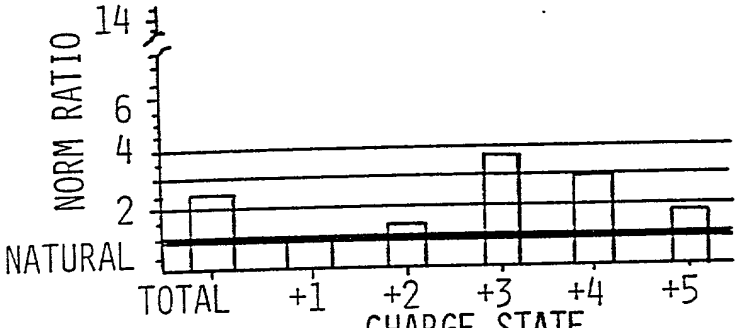


FIG.17A 200fs (NIR), $1X10^{14}W/cm^2$

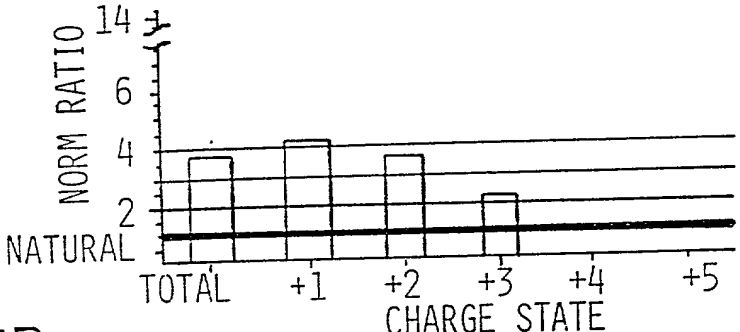


FIG.17B 6 ns (IR), $1X10^{11}W/cm^2$

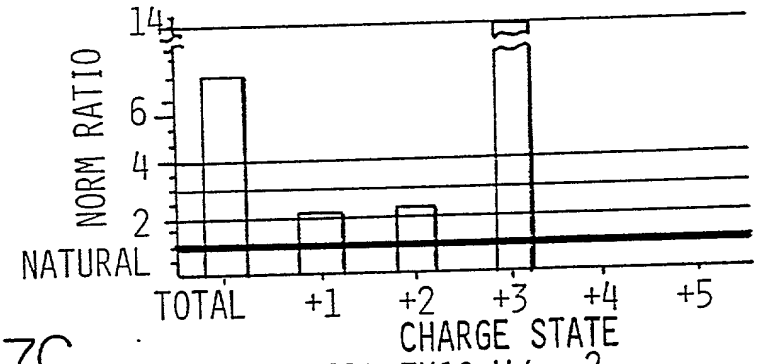


FIG.17C 230 ps (NIR), 3X10 W/cm^2

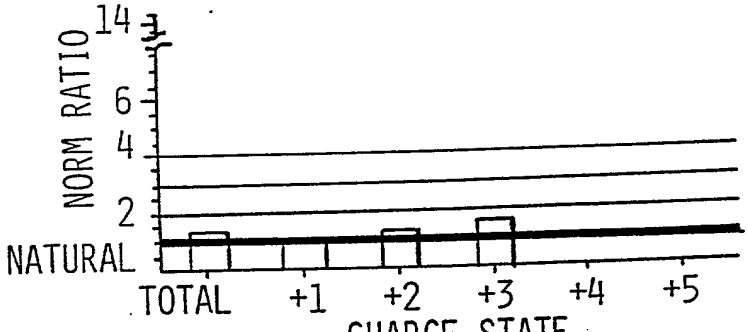


FIG.17D 6 ns (UV), $4X10^9$ W/cm^2

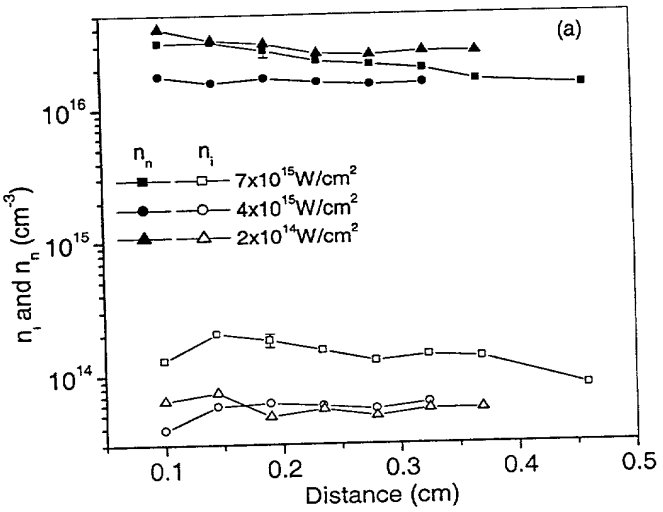


FIG. 19A

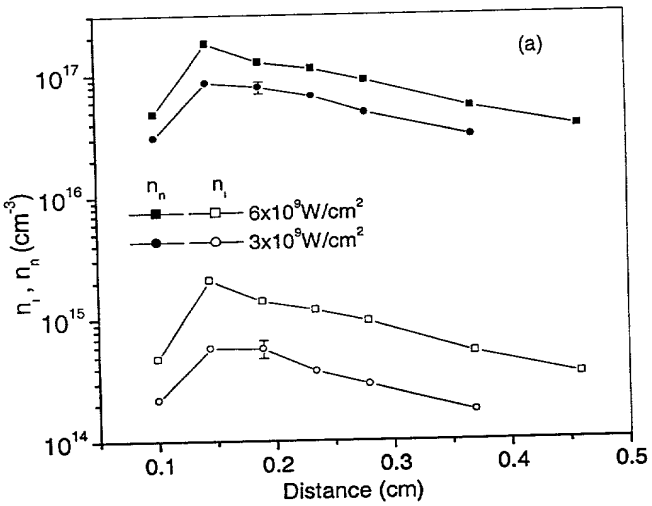


FIG. 19B

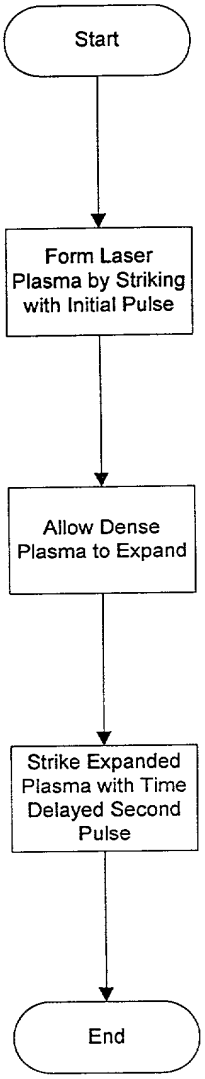

Start
Form Laser Plasma by Striking with Initial Pulse
Allow Dense Plasma to Expand
Strike Expanded Plasma with Time Delayed Second Pulse
End

FIG. 20

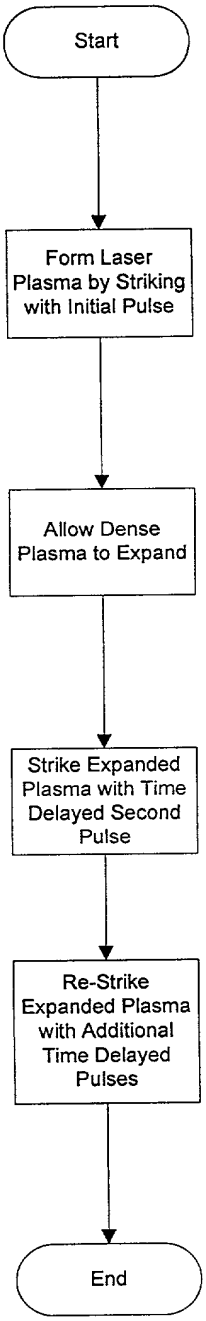

Start
Form Laser Plasma by Striking with Initial Pulse
Allow Dense Plasma to Expand
Strike Expanded Plasma with Time Delayed Second Pulse
Re-Strike Expanded Plasma with Additional Time Delayed Pulses
End

FIG. 23

FIG. 21

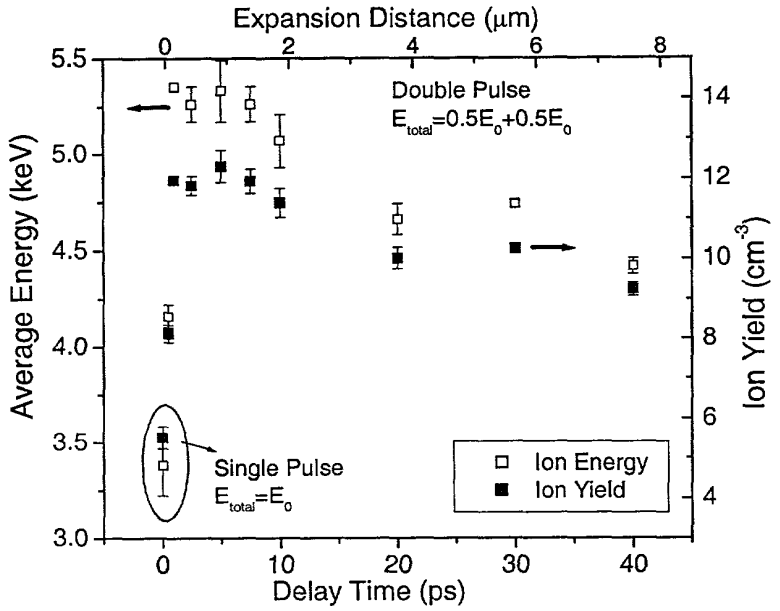


Fig. 1. Average ion yield and energy as a function of time-delay between two identical 120 femtosecond ablation pulses on silicon. The single pulse at zero delay has an energy fluence of 2.2 kJ/cm^2 on a beam spot diameter of 42 microns. The two double pulses have a fluence of 1.1 kJ/cm^2 each. Expansion distance based on measured average ion velocity of 1.9x10^{7}cm/s

FIG. 22

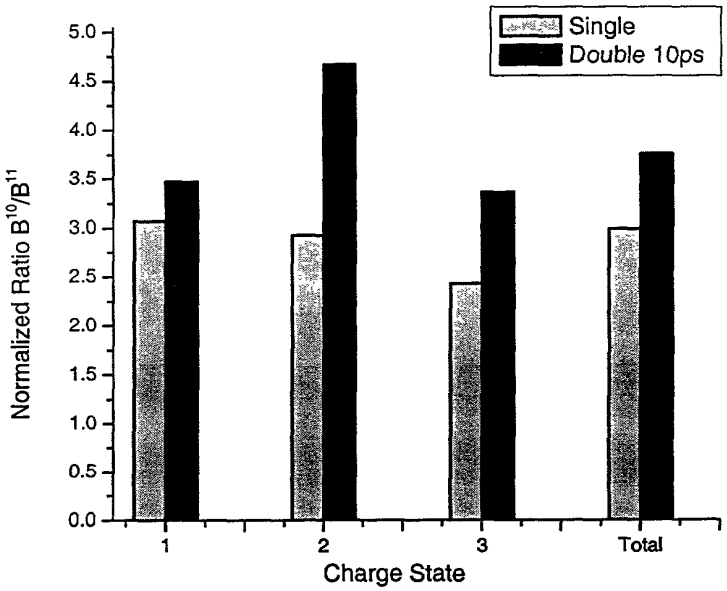


Fig. 1. Enhancement of isotope separation for boron ions in an ultrafast laser ablation plume. Single pulse: 2.2 kJ/cm^{-2}. Double pulse: 1.1 kJ/cm^{-2} each pulse, separated by 10 ps. Laser pulses are 120 fs, 780 nm at 10 Hz. Total laser intensity: 2x10^{16} W/cm^2. Natural abundance = 1.

FIG. 24

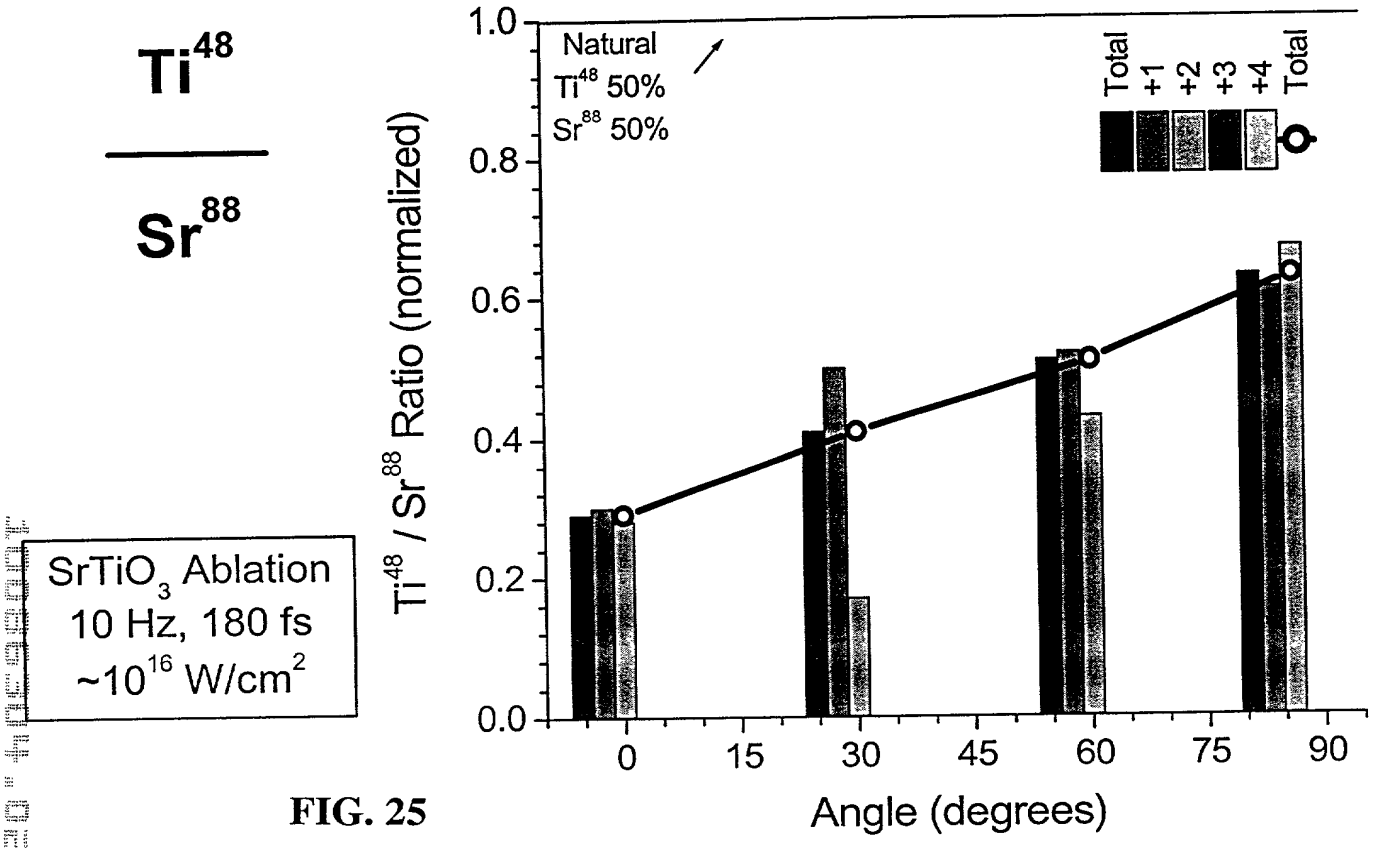

Ti48
Sr88
SrTiO3 Ablation
10 Hz, 180 fs
~10^16 W/cm^2
Natural
Ti48 50%
Sr88 50%
Total
+1
+2
+3
+4
Total
Ti48 / Sr88 Ratio (normalized)
1.0
0.8
0.6
0.4
0.2
0.0
0
15
30
45
60
75
90
Angle (degrees)

FIG. 25

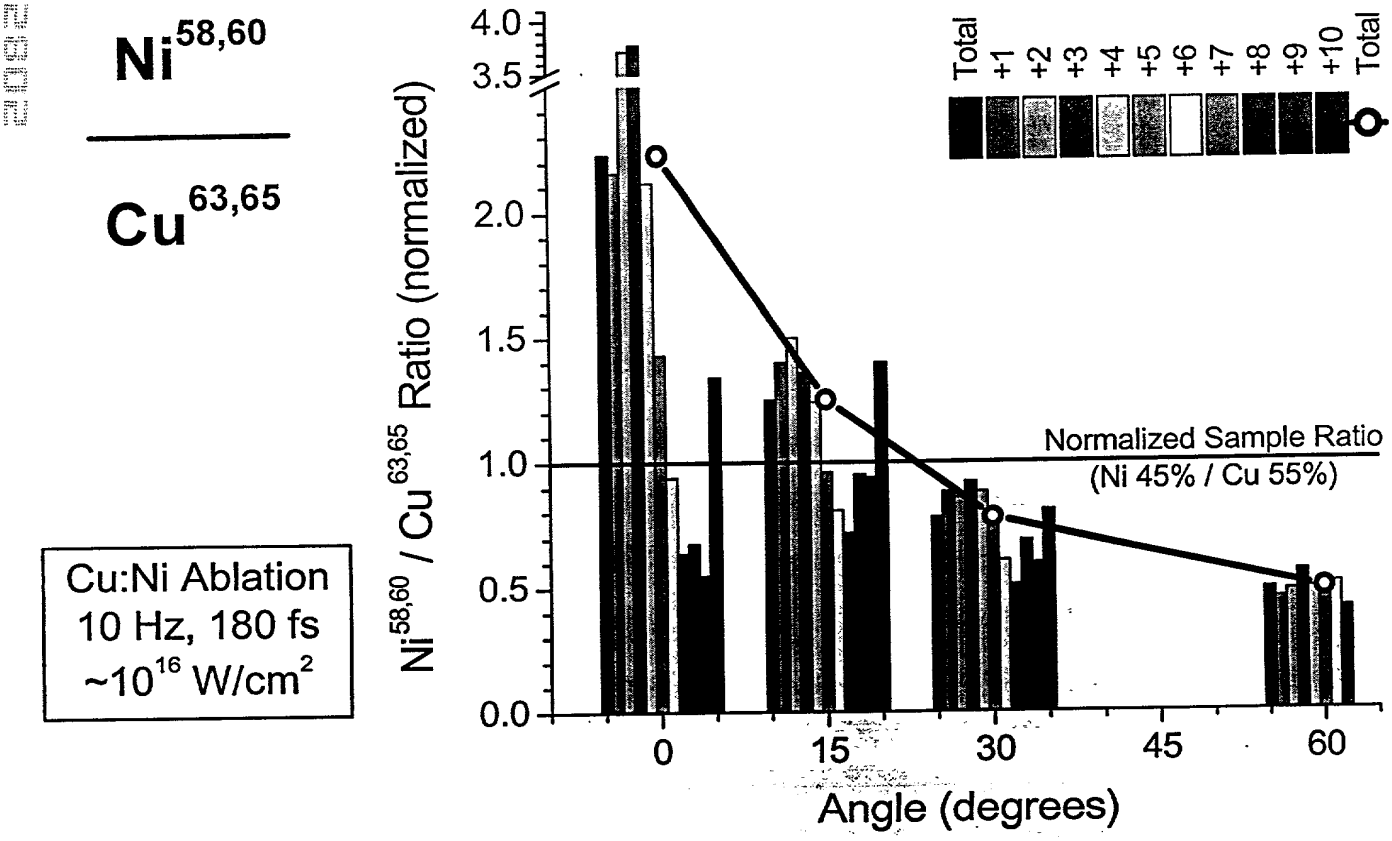

Ni58,60
Cu63,65
Cu:Ni Ablation
10 Hz, 180 fs
~10^16 W/cm^2
Total
+1
+2
+3
+4
+5
+6
+7
+8
+9
+10
Total
Normalized Sample Ratio
(Ni 45% / Cu 55%)
Ni58,60 / Cu63,65 Ratio (normalized)
4.0
3.5
2.0
1.5
1.0
0.5
0.0
0
15
30
45
60
Angle (degrees)

FIG. 26

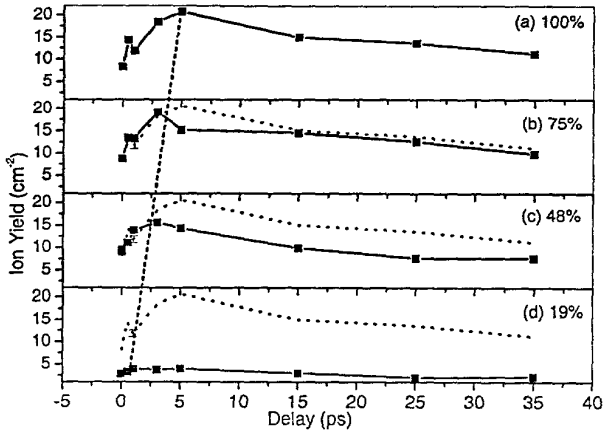


FIG. 27

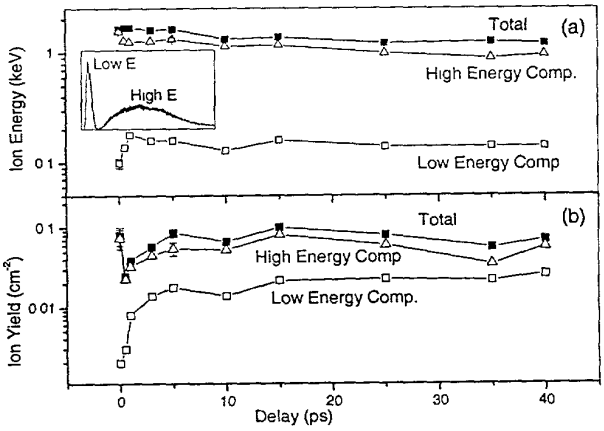


FIG. 28

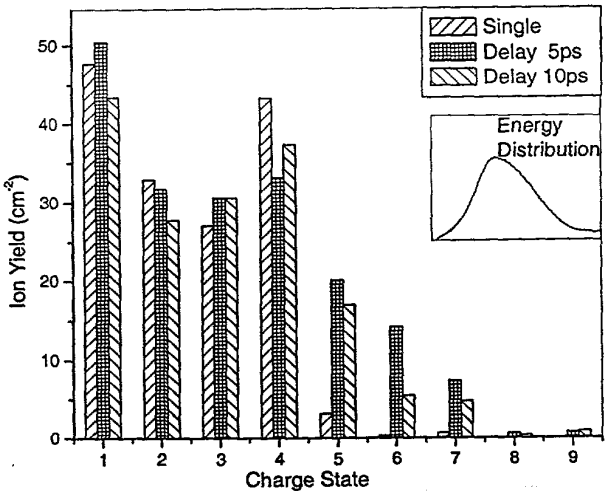


FIG. 29

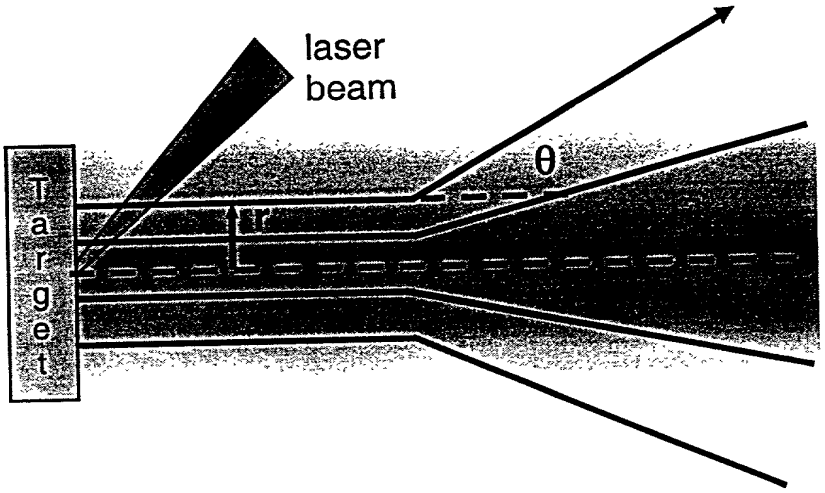

laser
beam
θ
Target

FIG. 30

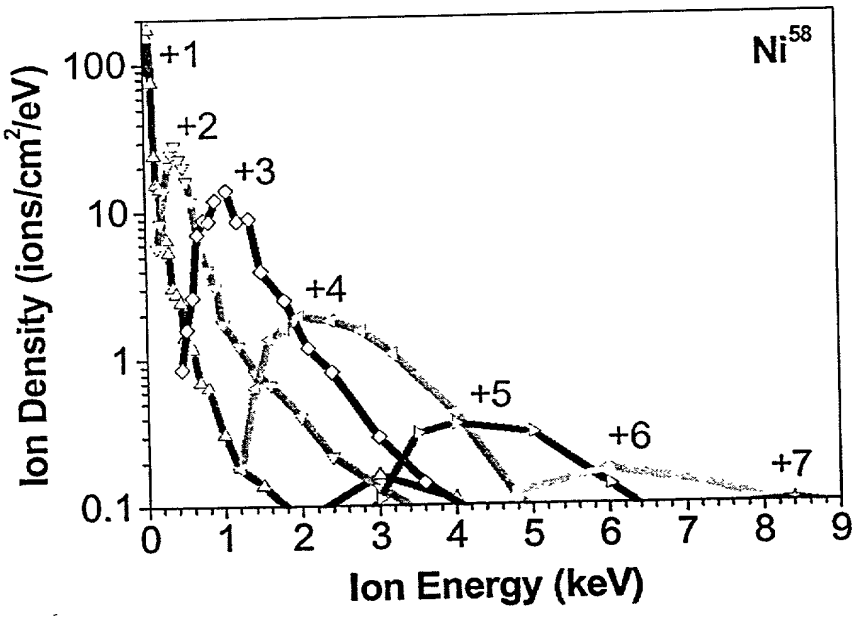

Ni58
+1
+2
+3
+4
+5
+6
+7
100
10
1
0.1
Ion Density (ions/cm2/eV)
0
1
2
3
4
5
6
7
8
9
Ion Energy (keV)

FIG. 31

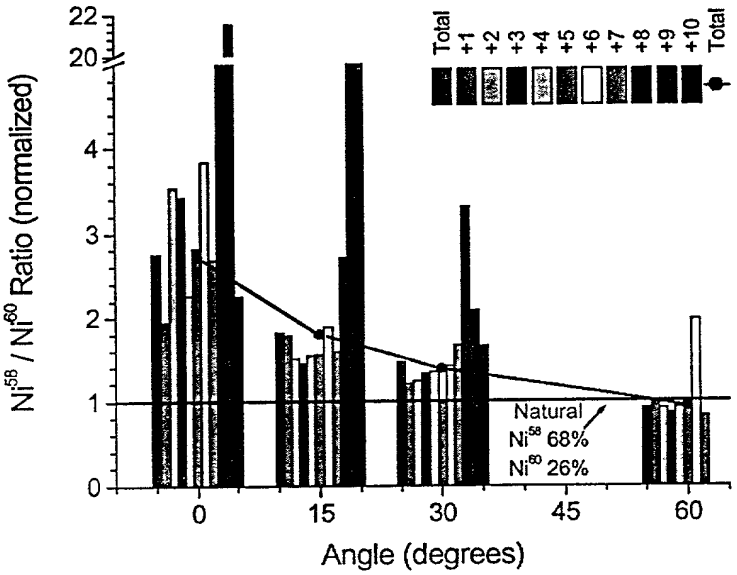
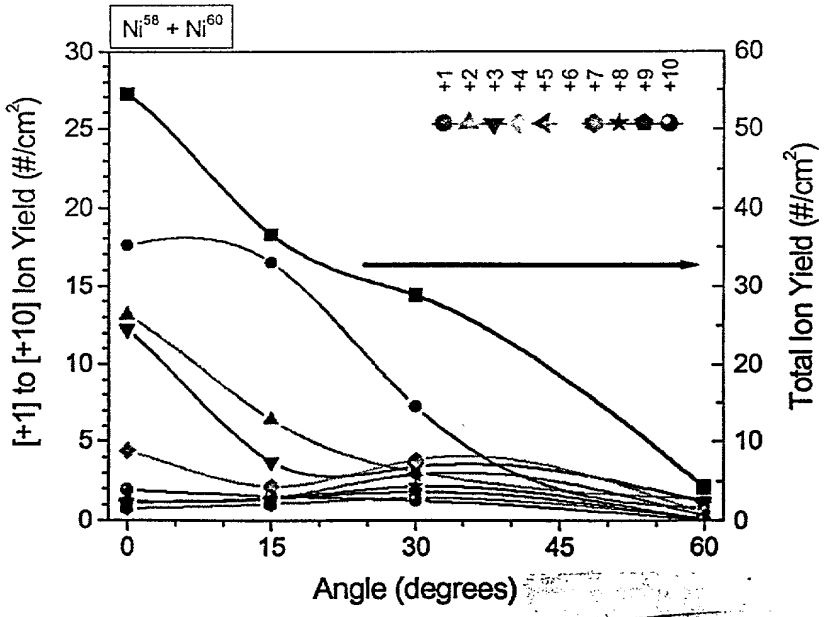

Total
+1
+2
+3
+4
+5
+6
+7
+8
+9
+10
Total
Ni58 / Ni60 Ratio (normalized)
Natural
Ni58 68%
Ni60 26%
Angle (degrees)

FIG. 32


Ni58 + Ni60
+1
+2
+3
+4
+5
+6
+7
+8
+9
+10
[+1] to [+10] Ion Yield (#/cm2)
Total Ion Yield (#/cm2)
Angle (degrees)